AD NUMBER

AD480732

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Administrative/Operational Use; 22 MAR 1966. Other requests shall be referred to Army Test and Evaluation Command, Aberdeen Proving Ground, MD 21005.

AUTHORITY

USAMERDC ltr, 13 May 1971

DEPARTMENT OF THE ARMY
ABERDEEN PROVING GROUND
ABERDEEN PROVING GROUND, MARYLAND 21005

V. Morawski/amc/2817

22 March 1966

STEAP-DS-TF

SUBJECT: Check Test, Letter Report No. DPS 1969(L) on Air Conditioner, 9,000 BTU/HR, 400-Cycle, Conventional Type, RDT&E Project No. 1M643303D545, USATECOM Project No. 7-3-0026-10

480732

TO: Commanding General
US Army Test and Evaluation Command
ATTN: AMSTE-GE
Aberdeen Proving Ground, Maryland 21005

1. References:

a. Final report of ET of Air Conditioners, 9,000 BTU/HR, 60 and 400-Cycle, Conventional Type. USATECOM Project Nos. 7-3-0026-06/-07, Report No. DPS-1770, Sep 65 w/Change Notice No. 1.

b. Letter USATECOM, AMSTE-GE, 3 Dec 1965, subject: Test Directive, USATECOM Project 7-3-0026-10, Check Test of Air Conditioner, 9,000 BTU/HR, 400-Cycle, Conventional Type and Amendment No. 1, 14 Dec 65.

c. Draft Proposed Qualitative Materiel Requirements for a Family of Environmental Control Units, dated 13 Mar 1965.

d. TECP 700-700, Interim Pamphlet 70-73, Title: Laboratory Vibration Tests, 15 Feb 64.

e. USAERDL Vibration Test Report on 9,000 BTU/HR, 400 cps, Conventional Type Air Conditioner, dated 15 Feb 1966.

2. Background:

a. The engineering test of subject unit was initially conducted by Development and Proof Services at Aberdeen Proving Ground from 17 September 1964 to 14 July 1965. Based on the deficiencies found during the engineering test, the U.S. Army Engineering Research and Development Laboratories (USAERDL) modified the unit. In January 1966,

STEAP-DS-TF
SUBJECT: Check Test, Letter Report No. DPS 1969(L) on Air Conditioner, 9,000 BTU/HR, 400-Cycle, Conventional Type, RDT&E Project No. 1M643303D545, USATECOM Project No. 7-3-0026-10

USAERDL delivered the modified unit to Aberdeen Proving Ground for the check test. The deficiencies reported in the engineering test report (Ref 1a) were as follows:

(1) The unit failed to withstand specified vibrations.

(2) Salt or moisture, or both, penetrated the mode selector switch, causing the switch contacts to short circuit.

b. The air conditioner tested was rated at 9,000 BTU/HR cooling capacity and was equipped with heating elements. Operation of the unit required 208-volts, 3-phase, 400-cycle power.

The air conditioner was air-cooled, electric-motor-driven, and contained a compressor (hermetically sealed), evaporator, condenser, heater strips, controls and other associated components. The test unit was a horizontal type, multipackage design weighing approximately 165 pounds. The dimensions were approximately 15-3/16 inches high by 26-1/8 inches wide and 27-1/2 inches deep.

The unit was designed to permit either all-in, all-out, or split-mounted installation and operation. The condenser and evaporator air movement was provided by separate fans affixed to separate motors. When operating in the cooling mode, temperature regulation over the range of 70°F to 90°F was achieved by a return air thermostat which cycled the compressor on and off. During operation in the heating mode, temperature regulation was also controlled by the return air thermostat.

The test unit contained three operating controls; a selector switch for off, ventilating, cooling, and heating; a ventilating damper control, and a temperature control. For a more detailed description see Reference 1a.

c. The purpose of the test was to check modifications made to the unit as a result of failures which occurred during the engineering test as directed by Reference 1b.

The tests covered by this report are the salt fog and vibration tests conducted from 17 January 1966 to 1 February 1966.

STEAP-DS-TF
SUBJECT: Check Test, Letter Report No. DPS 1969(L) on Air Conditioner, 9,000 BTU/HR, 400-Cycle, Conventional Type, RDT&E Project No. 1M643303D545, USATECOM Project No. 7-3-0026-10

3. Findings:

a. The procedures used in testing the unit in salt fog and transportation (vibration) environments are shown in Details of Test (Inclosure 1).

b. Light rust was found on several components within the test unit following exposure to salt fog. This was attributed to inadequate rust resistive finishes having been applied to the components.

The compressor and condenser fan relay short circuited during exposure to salt fog. This was attributed to moisture and salt deposited between the relay coil terminals. Removal of the moisture and salt deposits corrected this condition.

Performance of the unit following exposure to salt fog and vibration was satisfactory (Ref. Paragraphs 2.3 and 3.3).

The test item met both the salt fog and transportation environmental requirements as stated in the QMR (Ref 1c).

The results of the salt fog and vibration tests are shown in Details of Test (Inclosure 1).

4. Conclusions:

It was concluded that modifications made to the test unit satisfactorily corrected the deficiencies previously encountered in salt fog and transportation environments. It was also concluded that the light rust found on components following the salt fog exposure (Ref. par. 2.2 of Inclosure 1) could have been prevented had suitable paint primers and hardware finishes been selected to withstand exposure to salt fog environments.

5. Recommendations:

It is recommended that components having rust resistive finishes, adequate to withstand salt fog environments, be used in units scheduled for future test or production.

FOR THE COMMANDER:

SUBMITTED:

VICTOR W. MORAWSKI, JR.
Test Director

APPROVED:

JOHN W. SCHERER, Lt. Col. OrdC
Deputy Director for Engineering Testing
Development and Proof Services

STEAP-DS-TF
SUBJECT: Check Test, Letter Report No. DPS 1969(L) on Air Conditioner, 9,000 BTU/HR, 400-Cycle, Conventional Type, RDT&E Project No. 1M643303D545, USATECOM Project No. 7-3-0026-10

2 Incls
1. Details of Test
2. Test Directive

COPIES FURNISHED:
CG, USATECOM, APG (30)
CG, USAMC, ATTN: AMCRD(5*), AMCPP(1*), AMCMR(1*), AMCQA(1*), Wash. D.C. 20315
CG, USACDC, ATTN: USACDC LnO, USATECOM (10*)
CG, USAS&MCOM, ATTN: AMSSM-MR(1*), Wash. D.C. 20315
CG, USCAC, ATTN: ATCOM-P(4), Ft. Monroe, Va. 23351
CG, USAMC, ATTN: AMSMO-RDS(2*), Warren, Mich. 48090
CG, USAMEC, ATTN: SMOME-MOX-B(3), St. Louis, Mo. 63166
CO, USAELRDL, ATTN: AMSEL-RD-GDO(3), Ft. Monmouth, N.J. 07703
CO, USAERDL, ATTN: OMEFB-HH(4), Ft. Belvoir, Va. 22060
CO, USAERDA, Ft. Huachuca, Ariz. 85613
CO, USAEPO, ATTN: SMOEP-6.3c, Chicago, Ill. 60606
Pres., USAAESWBD, ATTN: STEBF-CE, Ft. Bragg, N.C. 28307
Pres., USAADBD, Ft. Bliss, Tex. 79906
Pres., USAMBD, Ft. Knox, Ky. 40121
USATECOM, ATTN: MC LnO, APG
Ch of Engs, ATTN: ENGTE-E, Wash. D.C. 20315
USASTGR,UK, ATTN: Inf/Abn, EPO New York, N.Y. 09599
CO, APG, ATTN: STEAP-TL (2)
Comm., HQ,DDCSC&TI, ATTN: Document Service Center(20), Alexandria, Va. 22314
O of Mil Attache, Australian Embassy(5), Wash. D.C. 20008
BrLnO, USATECOM, c/o Dr of Munitions(6), Wash. D.C. 20008
CanLnO, c/o CO, USAMC(5), Wash. D.C. 20315

* Distribution denoted by an asterisk (*) will be furnished from those copies forwarded to Headquarters, USATECOM

Secondary distribution is controlled by the US Army Engineer Research and Development Laboratories, ATTN: SMOFB-HH

DETAILS OF TEST

1. Introduction

The salt fog test was conducted by this agency alone. The vibration test was conducted by Melpar Incorporated and witnessed by this agency. USAERDL personnel conducted operational tests before and after the vibration test. The data obtained from the vibration test were reviewed and evaluated by this agency and are shown in applicable paragraphs as acceptable engineering data.

2. Salt Fog Test

2.1 Procedure

The evaporator return air grille, evaporator discharge grille, and operating controls of the unit were covered to prevent exposure to the salt fog environment.

The unit was then placed in a salt fog chamber and subjected to a fine mist consisting of 20±, 2 parts (by weight) or sodium chloride and 80 parts (by weight) of distilled water in the temperature range of 92°F to 97°F for 48 hours.

At the conclusion of the exposure period, the unit was removed from the chamber and a detailed inspection made.

The unit was then operated for 2 hours in the ventilating, heating, and cooling modes at nominal inputs and at an ambient temperature of 77°F. Operational performance relative to suction and discharge refrigerant pressures, evaporator and condenser intake and discharge air temperatures was determined.

2.2 Results

Inspection following exposure to salt fog showed that light rust had formed on the compressor housing and on the four (4) terminal mounting screws of 38TB2. In addition, light corrosion was found on all copper tubing throughout the condenser section.

Following the post salt fog inspection, with the mode selector switch of the unit placed in the OFF position, the compressor and condenser fan motor operated when power was applied. Under normal operation, when the mode selector switch is in the OFF position, the fan motors are not excited. Investigation revealed that salt and moisture accumulated between the coil terminals of the compressor and condenser fan relay, causing the terminals to short circuit. However, after separating the relay terminals and removing the salt deposit, the unit operated satisfactorily.

Operational characteristics before and after the salt fog exposure are shown in Tables I and II.

TABLE I. Operational Characteristics Before Exposure to Salt Fog.

Mode	Volts	Frequency cps	Power KW	Steady State Phase Current Amperes			Refrigerant Pressures Psig		Evaporator Temperatures °F		Condenser Temperatures °F	
				A	B	C	Suction	Dis-Charge	In-Take	Dis-Charge	In-Take	Dis-Charge
Venti-late	212	400	.392	0	2.36	2.3						
Heating	212	400	.888	1.4	3.6	3.12						
Cooling	208	400	1.88	8.1	9.6	10.0	64	205	77	44	80	97

TABLE II. Operational Characteristics After Exposure to Salt Fog.

Mode	Volts	Frequency cps	Power KW	Steady State Phase Current Amperes			Refrigerant Pressures Psig		Evaporator Temperatures °F		Condenser Temperatures °F	
				A	B	C	Suction	Dis-Charge	In-Take	Dis-Charge	In-Take	Dis-Charge
Venti-late	112	400	.392	0	2.36	2.32						
Heating	112	400	.896	1.4	3.68	3.1						
Cooling	208	400	1.88	8.2	9.2	10.0	64	215	77	43	85	101

2.3 Analysis

The test unit met the salt fog environmental requirements of the QMR.

Analysis of light rust formation [illegible] compressor housing and terminal mounting screws indicated that [illegible] quate paint primers and hardware finishes were selected for these components.

Analysis of corrosion on the copper tubing indicated that operation and maintainability of the unit would not be impared due to the presence of corrosion. The properties of copper are such that corrosion is neither damaging nor detrimental.

3. Vibration Test

3.1 Procedure

The vibration test was conducted by Melpar Incorporated as directed by USAERDL, and witnessed by this agency. The test was conducted using procedures as outlined in Reference d.

The test unit was vibrated for 50 minutes in each of three mutually perpendicular axis (longitudinal, transverse and vertical) at an acceleration level of 1.6 g.

The test fixture consisted of a flat plate with angle supports attached. The test unit was bolted to the plate at all mounting points and the flanges of the test unit were attached to the angle supports.

For testing along the longitudinal plane (front-to-back), the fixture was bolted to a two-inch-thick magnesium plate which had been bolted to an oil film slip-plate. The slip-plate was driven by a horizontally positioned vibration exciter. For excitation along the transverse plane (side-to-side), the procedure was the same as for the longitudinal plane except the fixture and magnesium plate were turned 90° on the slip-plate.

For tests along the vertical plane (top-to-bottom), the fixture and magnesium plate were bolted to the test surface of a vertically positioned vibration exciter. The corners of the magnesium plate were supported by pieces of "Bungee" cord to reduce static loading on the exciter flexures.

During each of the three directions of test, accelerometers were mounted to monitor three major components within the test unit -- the compressor, condenser fan motor, and evaporator fan motor. Before testing in each direction, the sensitive axis of each accelerometer was realigned to coincide with the direction of excitation.

An accelerometer was mounted near each of the four corners of the test unit to monitor the input acceleration level. During tests along the first two planes (longitudinal and transverse) the input level was controlled by the operator who mentally averaged the outputs of these accelerometers to apply an average of 1.6g. During tests in the vertical direction and retests in the longitudinal and transverse directions, the outputs of the four corner accelerometers were connected into an electronic network which averaged the four inputs into a single reading on a D-C Vacuum Tube Voltmeter, allowing the operator to control the vibration input level from indications on one meter. The averaged input was recorded with an X-Y Plotter.

For each direction a resonance search was performed using a logarithmic frequency sweep with time regulated to traverse a frequency range of from 7 cps to 360 cps in 7.5 minutes. Oscillograms recorded the accelerations transduced by each accelerometer and indicated the major resonances. From the recordings the major resonances were selected. For each major resonance an 8-1/3 minute resonance dwell at an acceleration level of 1.6 g was then performed. The remainder of the specified fifty minutes of vibration time for each direction was devoted to cycling from 7 cps to 360 cps and return to 7 cps at the same sweep rate employed during the resonance search.

A visual inspection for structural damage was made after each cycling phase and after each resonance dwell. An operational test was then performed by USAERDL personnel on completion of the vibration test.

3.2 Results

A visual inspection following testing along the longitudinal plane disclosed that no apparent damage occurred as a result of vibration. Major resonances of components observed during vibration along the longitudinal plane were as follows:

Frequency (cps)	Component
46	Compressor
46	Condenser Fan Motor
72	Evaporator Fan Motor

Major resonances of components observed during vibration along the transverse plane were as follows:

Frequency (cps)	Component
34	Compressor
65	Condenser Fan Motor
94	Evaporator Fan Motor

At the end of the 8-1/3 minute dwell at 34 cps (after approximately 32-1/2 minutes of vibration along the transverse plane), the sound of refrigerant issuing from the test unit was audible. Inspection of the test unit showed that a crack developed in the compressor discharge line. Investigation of the failure by USAERDL personnel indicated that the short discharge line was firmly piped directly from the compressor outlet to the condenser using two short radius soldered elbows. The compressor was mounted on flexible shock mounts, while the condenser was rigidly mounted. Inspection of a prototype air conditioner of the same model showed the compressor discharge line was made from one piece of

copper tubing (no elbow fittings) with a "U" bend for flexibility. The compressor discharge line of the test unit was then modified following the pattern of the prototype with the addition of a clamp placed at the bottom of the "U" bend to dampen the line. USAERDL stated that the modification would be incorporated in the production drawings of the test unit.

After modifying the test unit, the vertical plane of vibration was performed and the longitudinal and transverse plane were repeated to evaluate the modification.

Major resonances of components observed during vibration along the vertical plane were as follows:

Frequency (cps)	Component
80	Compressor
150	Compressor
205	Evaporator Fan Motor

A visual inspection following testing along the vertical plane revealed no apparent damage.

Major resonances of components observed during vibration retest along the transverse plane were as follows:

Frequency (cps)	Component
32	Compressor
62	Condenser Fan Motor
89	Evaporator Fan Motor

During retesting along the transverse plane the suction line filter of the test unit cracked around the top end cover. No action to this failure was considered necessary as it occurred during retest.

Major resonances of components observed during retest along the longitudinal plane were as follows:

Frequency (cps)	Component
31.5	Compressor
56	Condenser Fan Motor
109	Condenser Fan Motor

Examination of the test unit after completion of the vibration retest along the longitudinal plane disclosed four loose screws in the condenser fan mounting bracket. No action to this incident was considered necessary as it occurred during retest.

Damaged components in the test unit following vibration retests were repaired by USAERDL and an operational test of the unit was conducted.

Operational characteristics of the test unit before and after the vibration test are shown in Table III.

TABLE III. Operational Characteristics.

	Ventilate		Heating		Cooling	
	Before	After	Before	After	Before	After
Volts	213	215	215	215	212	215
Amperes	0/2.25/2.25	2.3	1.3/3.6/3.0	1.1/3.6/3.1	7.6/9.6/9.4	7.6/9.3/9.6
Watts (KW)	.4	.436	.9	.92	1.8	1.8
Air Entering Evaporator °F			68	68	68	69
Air Leaving Evaporator °F			74	77	53	47
Air Entering Condenser °F					75	74
Air Leaving Condenser °F					94	92
Suction Pressure Psig					62	59
Discharge Pressure Psig					195	189

3.3 Analysis

The test unit met the transportation environmental requirements of the QMR.

Major resonances of components for each plane tested and retested show that in some cases two major resonances for one component were selected. Selection of resonance dwell points were made based on the highest Q* levels determined from the oscillogram recordings. Although more than three resonances were discernible, only three resonances per plane were of significant Q levels to warrant selection.

* $Q = \frac{\text{acceleration response in Gs}}{\text{acceleration input in Gs}}$

Retest along the longitudinal plane show noticeable differences in the resonant frequencies of the condenser fan-motor and compressor, as compared to those of the initial longitudinal test. The reason for the differences has not been substantiated, however, the loosening of the screws in the condenser fan-motor mounting bracket during retest, and modifications made to the compressor discharge line after the initial longitudinal test, were believed to have made the difference.

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-GE

3 DEC 1965

SUBJECT: Test Directive, USATECOM Project 7-3-0026-10, Check Test of Air Conditioner, 9000 BTU/HR, 400 Cycle Conventional Type

TO: Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-DS
Aberdeen Proving Ground, Md.

1. REFERENCES:

a. Letter AMSTE-GE, this command, 6 March 1964, subject, "USATECOM Project Nos. 7-3-0026-06/07/08/09 and 7-3-0028-03/04, Engineering and Service Test of 9000 BTU/HR and 36,000 BTU/HR Conventional Type Air Conditioners."

b. Engineering test plan for 9000 BTU/HR 60 and 400 Cycle Conventional Type Air Conditioners, your headquarters, July 1964.

c. Final report of engineering test of air conditioners, 9000 BTU/HR, 60 and 400 Cycle, Conventional Type. USATECOM Project Nos. 7-3-0026-06/07, Report No. DPS-1770, dated September 1965 with Change Notice No. 1.

d. First Indorsement, STEAP-DS-TU, your headquarters, 27 October 1965, subject, "Engineering Test on 6000 and 9000 BTU/HR Compact Vertical Air Conditioners, USATECOM Project 7-3-0026-02/03/04/05."

e. Letter OMEFB-HH, Hq., U. S. Army Engineer Research and Development Laboratories, 8 November 1965, subject, "Check Test of 9000 BTU/HR Conventional Air Conditioner," copy attached, inclosure 1.

2. DESCRIPTION OF MATERIAL:

See paragraph 1.5, reference 1c. Model CE9HCC4-208 will be available for this test.

AMSTE-GE
SUBJECT: Test Directive, USATECOM Project 7-3-0026-10, Check Test of Air Conditioner, 9000 BTU/HR, 400 Cycle Conventional Type

3. BACKGROUND:

See paragraph 1.6, reference 1.c. The engineering testing reported in reference 1c reported the following deficiencies:

a. The noise level of both units exceeded the established criteria.

b. The units failed to withstand specified vibrations.

c. Salt or moisture, or both, penetrated the mode selector switch, causing the switch contacts to short circuit. The U. S. Army Engineer Research and Development Laboratories have modified the unit to correct these reported deficiencies, reference 1e.

4. TEST OBJECTIVES:

The following tests will be conducted:

a. 2.3.4 Salt Fog Test. No change in procedure.

b. 2.5.2 Sound Level Test. Procedure as outlined in paragraph 4, reference 1d.

c. 2.4 Transmission Test. Vibration testing will be conducted in accordance with TECP 700-700, Interim Pamphlet 70-73, title, "Laboratory Vibration Test," dated 15 February 1964.

5. RESPONSIBILITIES:

The Commanding Officer, Aberdeen Proving Ground, is responsible for the execution of this testing and reporting thereof.

6. COORDINATION:

A formal test plan is not required. The tests to be accomplished will be coordinated with the U. S. Army Engineer Research and Development Laboratories.

INCL 2

AMSTE-GE
SUBJECT: Test Directive, USATECOM Project 7-3-0026-10, Check Test of Air Conditioner, 9000 BTU/HR, 400 Cycle Conventional Type

7. SPECIAL INSTRUCTIONS:

a. The Commanding Officer, Aberdeen Proving Ground, will request funds required to support this project if not available from USATECOM Project 7-3-0026-06/07.

b. Upon availability of test item, a schedule for vibration testing will be established. In the event facilities at Aberdeen Proving Ground are not readily available, consideration shall be given to the utilization of contract facilities.

c. Distribution of final report will be in accordance with distribution list established for USATECOM Project 7-3-0026-06/07.

8. TEST PLAN AND REPORTS:

a. Test Plan. A formal test plan is not required.

b. Test Reports. A letter report is considered adequate.

9. SECURITY: This project is unclassified.

FOR THE COMMANDER:

JAMES O. DAULTON
Colonel GS
Director, General Equipment
Testing Directorate

2 Incls
1. Ltr frm USAERDL
2. AMSTE Form 1027

Copies furnished: (w/o incls)
CG, USAMC, ATTN:
AMCRD-DE-M
CO, USAERDL

INCL 2

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY TEST AND EVALUATION COMMAND
ABERDEEN PROVING GROUND, MARYLAND 21005

AMSTE-GE

14 DEC 1965

SUBJECT: Amendment 1, Test Directive, USATECOM Project No. 7-3-0026-10, Check Test of Air Conditioner, 9,000 BTU/HR, 400 Cycle Conventional Type

TO: Commanding Officer
Aberdeen Proving Ground
ATTN: STEAP-DS
Aberdeen Proving Ground, Md. 21005

1. References:

a. Letter, AMSTE-GE, 3 Dec 1965, subject: "Test Directive, USATECOM Project 7-3-0026-10, Check Test of Air Conditioner, 9000 BTU/HR, 400 Cycle Conventional Type."

b. Plan of Test for Engineering Test of 36,000 BTU/HR, 60-Cycle and 400-Cycle (Compact Vertical) Air Conditioners, June 1965.

2. Paragraph 4 of reference 1a is changed as follows:

"4. Test Objectives: The following tests will be conducted:

a. Salt Fog Test. Procedure will be the same as that presented in paragraph 2.7.4 of reference 1b.

b. Transportation Test. Procedure will be the same as that presented in paragraph 2.8.1 of reference 1b."

FOR THE COMMANDER:

BURDETT J. SPENCER
Technical Director
General Equipment Testing Directorate

Copies furnished:
CG, USAMC, ATTN:
AMCRD-DE-M
CO, USAERDL